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Quarterly Report

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Pipeline and Hazardous Materials Safety Administration
Office of Pipeline Safety

Project Title: "Understanding Magnetic Flux Leakage (MFL) Signals from Mechanical Damage in Pipelines"

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Background

In an effort to improve safety and minimize environmental impact, there is increasing emphasis of pipeline operators and inspection vendors to locate and accurately assess mechanical damage. Caliper tools can be used to predict sizes of simple dents, but cannot detect the presence of external gouging, corrosion pitting, stresses or cracking associated with those dents. MFL tools have the potential to characterize dents and gouges, but as yet the MFL signals from these features are not sufficiently understood to be used for reliable mechanical damage detection and characterization. In order to reliably use MFL tools for mechanical damage assessment, we need to understand the origin of the MFL signal from dents and gouges. This project addresses that need.

Technical Status

Work in this quarter was focused on Task 9 "Characterizing Magnetic Response of Gouged Pipeline Material" and Task 13 "Collaboration with DOT Project DTPH56-06-T-000016".

A number of additional test gouges of different sizes and severity have been produced on polished steel plate samples of dimensions 18" × 18" × 0.2" using a backhoe tool. To avoid complexity associated with residual magnetization caused by MFL measurements, two separate sets of samples were used, one exclusively for MBN work and the other for combined MBN as well as MFL measurements. For MBN measurements, the scratches with progressively severe surface stresses were introduced both in the rolling (axial) direction and transverse (circumferential) direction by using SiC papers of grit sizes 240, 180, 120, 80 and 60 followed by more severe sanding wheel scratches and backhoe gouge marks. A number of linear and angular MBN measurements were performed at different locations of the damaged sections to characterize magnetic response of scratched and gouged materials (Tasks 9.3). The MFL measurements were made on all the scratched and gouged samples to complement the results of MBN study (Tasks 9.4). The data produced from MBN and MFL measurements were analyzed to obtain preliminary information about the magnetic response parameters of damaged sections (Task 9.5). Although we have completed measurements both from laboratory and backhoe gouged samples, we feel the need to further analyze the results in order to be confident of the interpretation. This work should be completed by the end of the next quarter.

The work on structural finite element modeling of MD1-1 dents was extended to model pipeline sections with non-zero internal pressure. Separate structural models using cylindrical-shaped, wedge-shaped, and pointy indenters were produced. To verify the accuracy of structural modeling results, the work on cylindrical indenter model was subcontracted to Mr. Behrouz Shiari from Dept of Mechanical and Aerospace Engineering, Carleton University, Ottawa. The corresponding magnetic finite element modeling of cylindrical dent has been completed and the geometry component and stress component of the MFL signals have been modeled separately. The work on magnetic modeling of the other two types of dents is in progress (Task 13.2). An online meeting was held with PRCI Mechanical Damage working group.

Plans for Future Activity

The following work is planned for the next quarter:

- Gouge models will be developed using magnetic finite element modeling and the magnetic response parameters obtained from Task 9.5 will be introduced into the model (Task 9.6).
- Additional backhoe gouges will be produced and MBN and MFL measurements will be made to obtain reasonably satisfactory information about the complex stress structure within the heavily deformed gouged material. This work will allow us to refine the information obtained in the present quarter regarding the magnetic response parameters of gouged material.